§54. Erosion of First Wall Materials under High Flux Beam Irradiation

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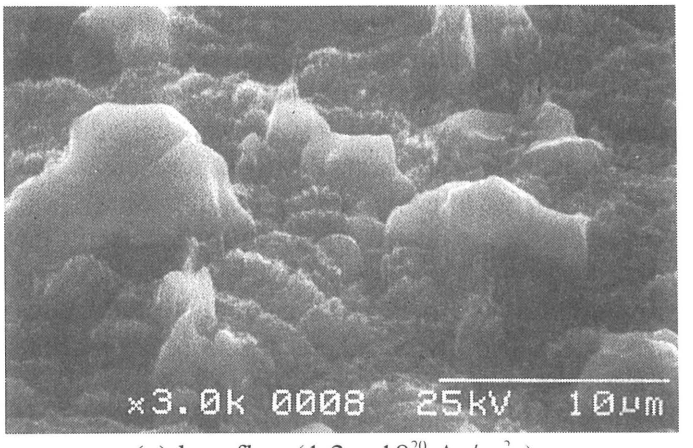
In the previous NIFS annual report[1], we have shown that the impact of radiation enhanced sublimation (RES) of isotropic graphite on the erosion of plasma facing components is significantly reduced under high flux irradiation condition, which is comparable to the actual edge plasma condition. The flux dependence of RES yield of our study (total yield subtracted by physical sputtering yield, $\phi^{-0.26}$) is very close to the model prediction ($\phi^{-0.2}$~ $\phi^{-0.3}$)[2].

The effects of crystal structure and dopants on the RES yield in high flux region is not well understood so far. In this report, high flux irradiation results on pyrolytic graphite (irradiated perpendicular to basal planes) and RG-Ti (recrystallized graphite with 1.7 at%Ti by 1D compression) are described. Irradiation was made by 5 keV Ar beam, which can simulate 0.5 keV D beam with the flux 50 times higher.

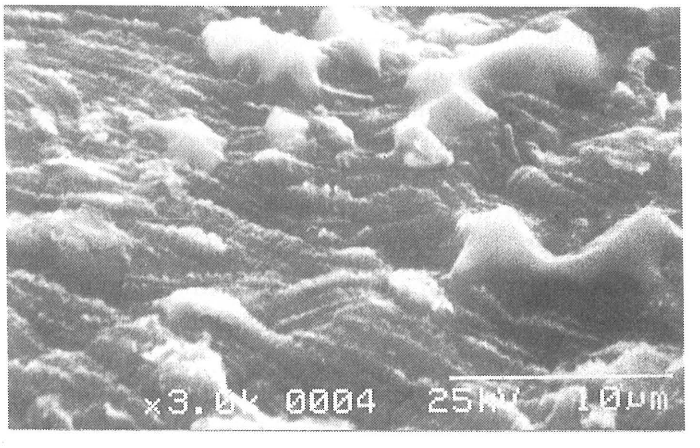
Pyrolytic graphite and RG-Ti show similar reduction of RES yield with flux (also similar to isotropic graphite). In detail, however, the absolute yield at 1980 K is slightly larger in pyrolytic graphite than isotropic graphite in low flux case (5×10^{19} $m^{-2}s^{-1}$), while the yield is nearly the same in high flux case (10^{21} $m^{-2}s^{-1}$). On the contrary, the absolute yield of RG-Ti at 1780 K is always lower than that of isotropic graphite by about 40%.

RG-Ti mainly consists of graphite layer, whose basal planes is almost parallel to the direction of compression, and TiC grains with the size of about 10 μm. Graphite layers are eroded by RES and physical sputtering, while TiC grains are eroded by only physical sputtering. This selective sputtering causes less erosion in TiC grains than the graphite layers, which would be the reason for less yield of RG-Ti than isotropic graphite.

Figure 1 shows the surface microstructure of RG-Ti after irradiation by low flux (a) and high flux (b). In both cases, crystalline structure of TiC came out on the surface after the irradiation. In the low flux case (Fig.1(a)), TiC grains of mean height of about 4μm appear with the total eroded depth of about 6 μm. On the other hand, in the high flux case (Fig.1(b)) the microstructure shows only a little ups and downs though the eroded depth is larger (8 μm). This result clearly illustrates the reduction of RES yield of graphite in high flux region, which does not act on TiC grains.



(a) low flux (1.2×10^{20} Ar/m^2s)



(b) high flux (8.0×10^{20} Ar/m^2s)

Fig. 1 Micrograph of irradiated RG-Ti at 1780 K.

References
[1] Ueda Y., Isobe M.,Nishikawa M.,Noda N., Ann. Rep. NIFS (1994-1995) 49.
[2] Davis, J. et al., to be published in J. Nucl. Mater. (presented at 12the PSI (1996)) .